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(54) Method of filling cans with substantially non-carbonated drinks

(57) Non-carbonated drinks are filled into thin-walled drawn aluminium cans which tend to collapse when they are not pressurised, by a method which comprises dissolving N_2 gas and CO_2 gas under pressure in a non-carbonated drink in a saturator 4, the weight ratio of the CO_2 gas to the drink being 15/10,000 or less; filling this drink into the cans in a filling machine 11 at the same temperature and pressure as the saturator 4, spraying N_2 or CO_2 gas-containing inert gas upon the upper surface of the drink in the cans while the drink is exposed to the atmosphere and then seaming the cans in a machine 12. The conditions under which the CO_2 and N_2 gases are dissolved in the drink, i.e. temperature, pressure, and CO_2 to N_2 ratio, are selected by reference to a series of can-internal pressure/temperature curves (Fig. 2), so that the can internal pressure after filling and seaming have been completed falls within the predetermined strength range of the cans and therefore that the cans are not burst by excessive internal pressure during pasteurising and do not collapse inwards at the lower drinking temperature when handled.
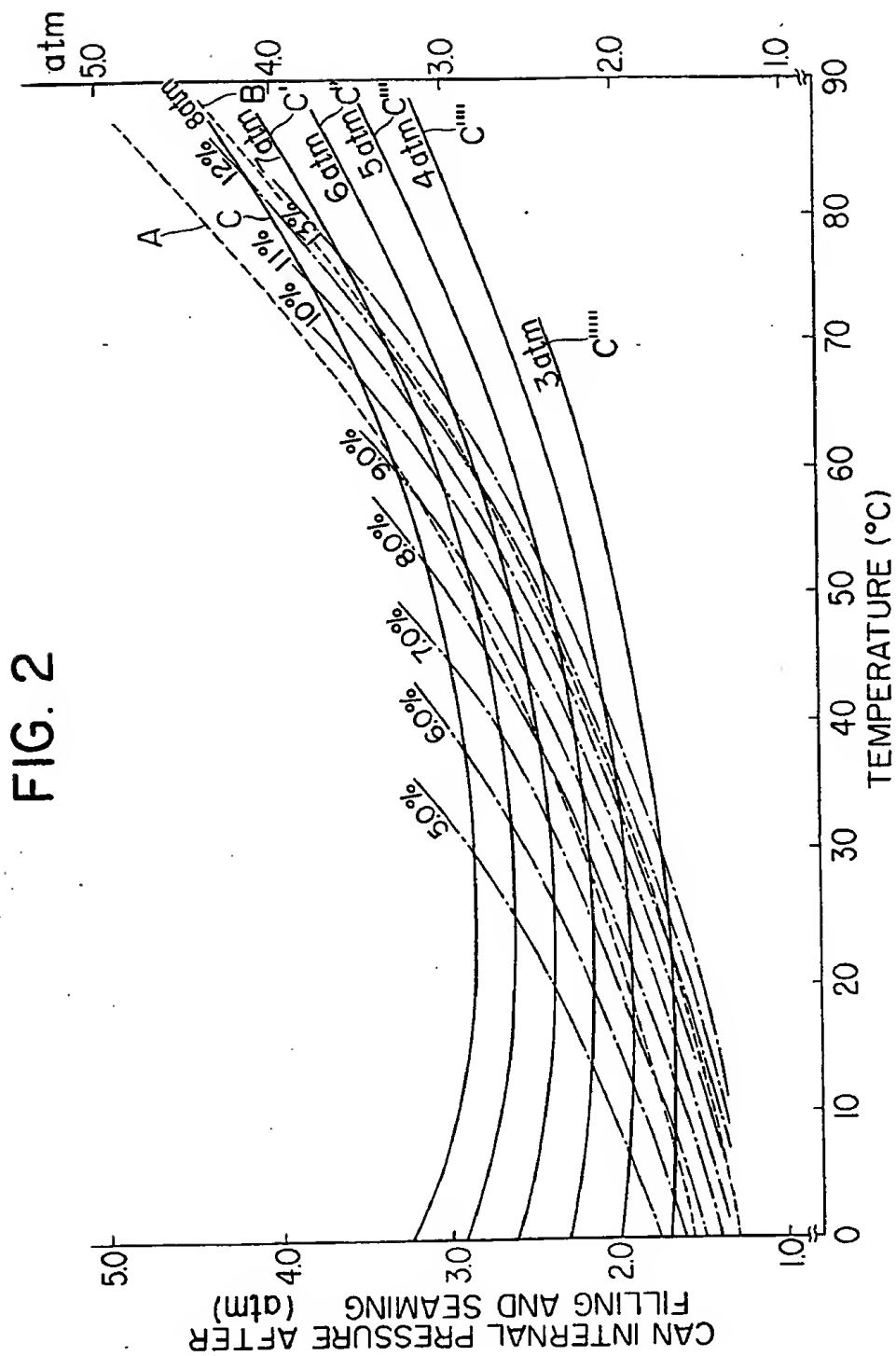
FIG. 1

FIG. I

N2 GAS

FIG. 2
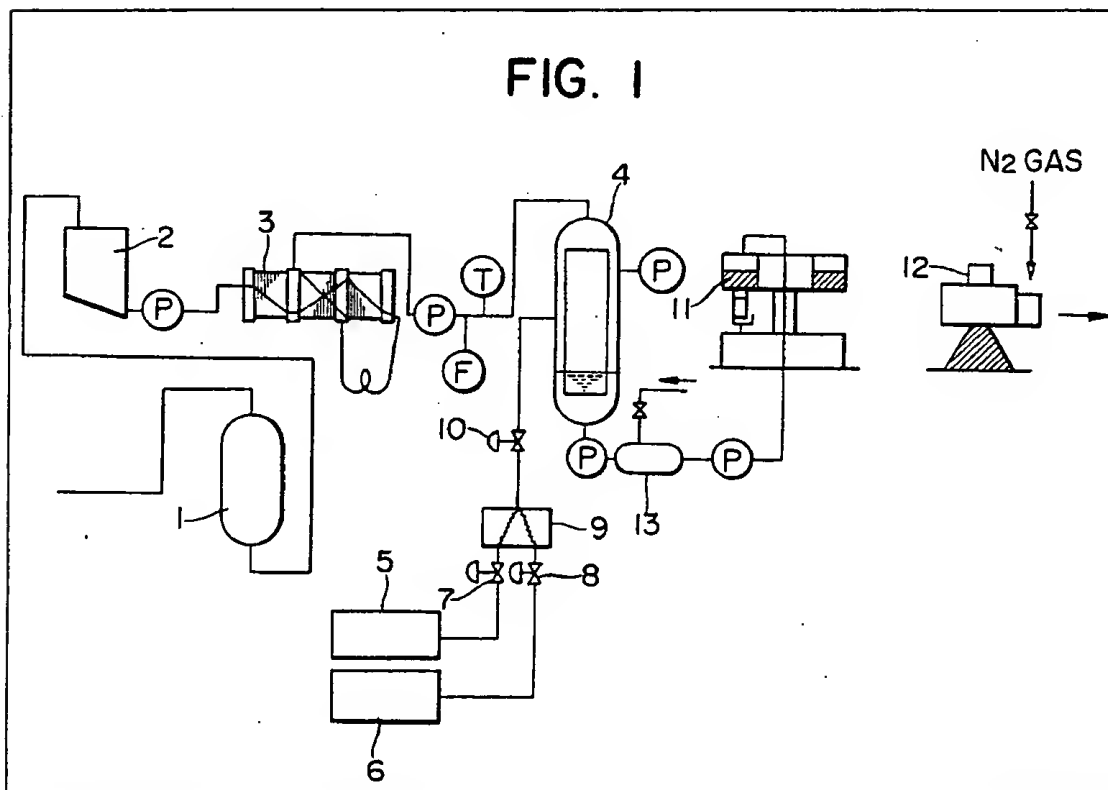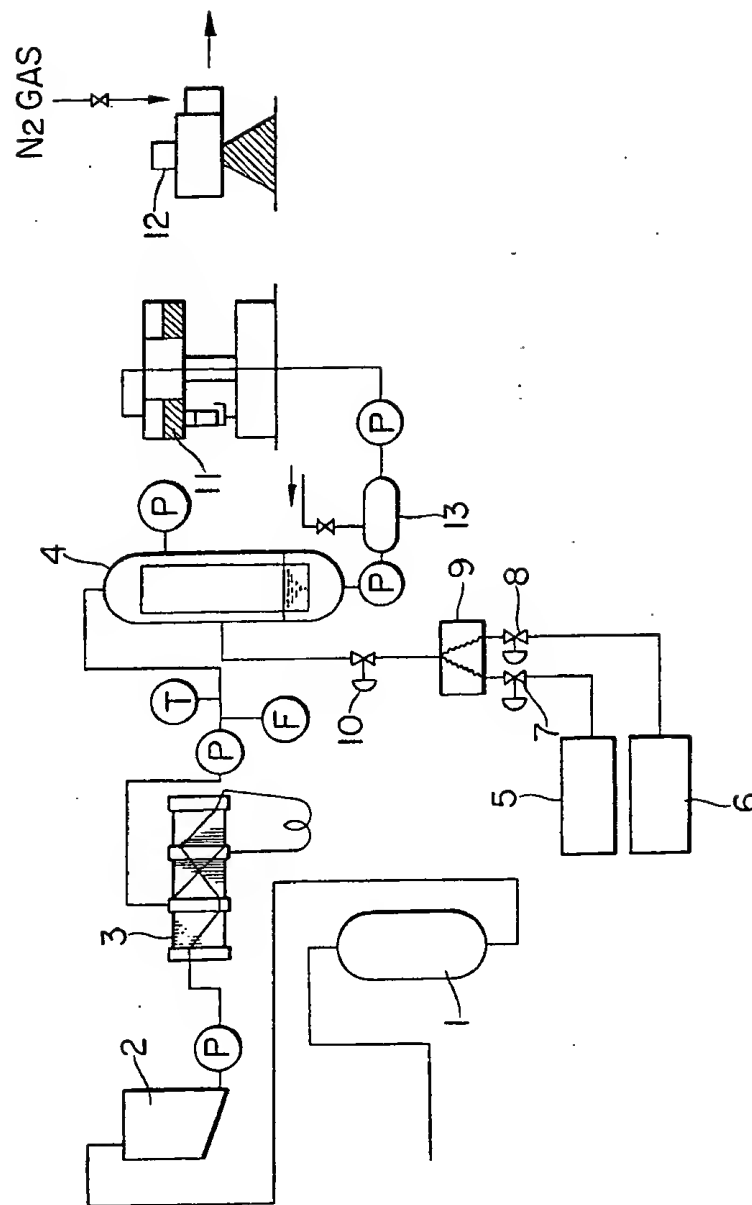
SPECIFICATION

Method of filling cans with substantially non-carbonated drinks

5 The present invention relates to a method of filling "soft" thin-walled cans with so-called non-   5
fizzy drinks, namely substantially non-carbonated drinks such as fruit juice, coffee, wine, cocoa,
lactobacillus drink, black tea, rice wine (sake), soup, tea, barley tea, isotonic drinks and still
mineral water.
   In general, "soft", thin-walled cans, typically drawn aluminium cans have been widely used in
10 place of tinned steel cans for carbonated drinks containing a substantial quantity of carbonic   10
acid gas, for example beer and soda water. This is because the former are superior due to their
reduced weight, ease of processing a two-piece can in stack-in and neck-in shapes, high
recovery-renewal efficiency and expectation of improved product quality as compared with the
latter.
15   These soft thin-walled cans, for example of aluminium, when used for holding carbonated   15
drinks, can maintain their original shapes against atmospheric pressure because the internal
partial pressure of the carbonic acid gas holds the internal can pressure, after filling and
seaming have been completed, substantially above atmospheric pressure, even when cooled at
the time of drinking, whereas such cans, when used for containing non-carbonated drinks, are
20 defective because the partial pressure produced in the case of carbonated drinks is not present   20
and therefore the can internal pressure may fall below the atmospheric pressure when the cans
are cooled after the completion of the filling and seaming operations. Since the "soft" thin-
walled cans have little strength against the external pressure, the cans are unable to hold their
original shapes and thus distort or are readily bent by finger pressure when grasped.
25 Accordingly, thin-walled cans, especially aluminium cans, have not generally yet been used for   25
non-carbonated drinks in spite of their various advantages.
   Trials of holding non-carbonated drinks in "soft" thin-walled cans, have been made here and
there. Amongst these trials, for instance, is a method of canning comprising subjecting a
blended non-carbonated drink to pasteurization at a temperature of about 95°C, thereafter
30 cooling the drink to 5°C or less, dissolving N_2 gas therein at this cooled temperature, filling and   30
seaming the can, and then heating the drink again to 60°C for sterilizing any mould or bacteria
present therein (see Japanese Laid Open Patent Application No. 72675/1981). However, this
method is not very practical owing to the great energy loss caused by the essential steps of
dissolving N_2 gas in the drink, filling the drink into cans at the low filling temperature of 5°C or
35 less, and then heating the drink again for sterlization after the completion of filling and seaming,   35
that is closure and sealing, of the can.
   A method has also been proposed which comprises dropping liquefield N_2 into a drink-filled
can before the can is seamed, and then seaming the can while simultaneously spraying N_2 gas
over it (see Japanese Laid Open Patent Application No. 4521/1981). However, this method
40 has not been used industrially at all because it is difficult to control the liquefield N_2.   40
   Still further, some of the inventors of the present invention have previously proposed a filling
method which includes dissolving a mixed gas consisting of a very small quantity of CO_2 gas
with N_2 gas in the drink (see Japanese Laid Open Patent Application No. 99183/1977).
However, this method is a mere idea formed on the basis of the conjecture that the use of a
45 mixed gas consisting of a very small quantity of CO_2 gas with N_2 gas may permit utilization of   45
the partial pressure caused by the CO_2 gas contained in a very small quantity in the drink to
raise the internal pressure of the can to prevent the can from deforming under external
atmospheric pressure. Additionally, as this method does not disclose the filling conditions which
should be observed, for example the temperature for filling, the proportion of CO_2 in the mixed
50 gas the pressure at which the mixed gas is dissolved, and other conditions, it has not yet been   50
practiced industrially.
   It is an object of the present invention to provide a method of filling "soft" thin-walled cans,
for example of aluminium, with substantially non-carbonated drinks, under conditions such that
the original can shape is maintained after the cans have been seamed and during the course of
55 subsequent handling.   55
   To this end, according to the invention we provide a method of filling a "soft" thin-walled
can, for example an aluminium can, with a substantially non-carbonated drink, in which method
N_2 gas and CO_2 gas are dissolved under pressure in the drink so that the weight ratio of CO_2 to
the drink is a predetermined value which is not more than 15/10,000, a predetermined
60 quantity of the drink is then introduced into the can at the same temperature and pressure at   60
which the N_2 and CO_2 gases were dissolved in the drink and N_2 gas and/or a CO_2 containing
inert gas is supplied over the surface of the drink in the can, substantially replacing the air in
the head space of the can, while the can is open between the filling and sealing of the can, the
temperature, pressure and CO_2 to N_2 ratio at which the CO_2 and N_2 gases are dissolved in the
65 drink having been determined by establishing, for the sealed can filled with the predetermined   65

quantity of a drink containing dissolved CO_2 and N_2 gases with the predetermined weight ratio of CO_2 to the drink, an upper can internal pressure—temperature curve passing through a predetermined maximum pressure at e selected high temperature and a lower can internal pressure—temperature curve passing through a predetermined minimum pressure at a selected
5 low temperature to define a permissible can internal pressure—temperature range, a first series   5
of can internal pressure—temperature curves assuming the dissolving pressure to be held constant at a series of different values at and below the predetermined maximum can internal pressure, and a second series of can internal pressure—temperature curves assuming the CO_2 to N_2 ratio to be held constant at a series of different values, and determining the dissolving
10 pressure and the CO_2 to N_2 ratio et a selected temperature from any curve of the first and   10
second series which lies within the permissible can internal pressure—temperature range at the selected temperature.

The predetermined maximum can internal pressure may be 8 atmospheres and the selected high temperature may be the highest temperature the filled and seamed can is likely to be
15 subjected to, for example 120°C in a subsequent pasteurisation stage. Similarly, the predeter-   15
mined minimum can internal pressure may be 1.1 atmospheres, preferably 1.4 atmospheres, and the selected low temperature may be the temperature to which the drink may be cooled for drinking, e.g. 5°C.

The method may permit higher temperature filling and thus may decrease heat losses as
20 much as possible in the steps of pasteurisation, filling and seaming, and subsequent further   20
pasteurisation if this is necessary. The filling temperature may be from 20°C to 81°C, preferably between 50°C and 65°C, and most preferably 60°C.

The method may also be carried out in such a way that conventional carbonated drink filling machinery and filling lines can be used, thus avoiding the necessity for the provision of special
25 equipment. The method thus enables effective utilization of conventional machines and at the   25
same time standardization of filling lines for carbonated and non-carbonated drinks and of the cans used therefor.

An example of a method in eccordance with the invention will now be described with reference to the accompanying drawings, in which:-
30   Figure 1 is a flow diagram of apparatus for carrying out the method in eccordance with the   30
invention; and,

Figure 2 is a series of graphs illustrating the relationship between the internal pressure in the cans and temperature unde various conditions and from which the operating parameters of the method can be determined.
35   The drinks to be filled into cans by the method in accordance with the present invention are   35
so-called non-fizzy drinks, namely non-carbonated drinks, for example fruit juice, coffee, black tea, cocoa, lactobacillus drink, wine, rice wine (sake), soup, tea, barley tea, isotonic drink and still mineral water. These non-carbonated drinks are filled into soft thin-walled cans, typically aluminium cans.
40   With reference to the flow diagram shown in Fig. 1, the non-carbonated drink, such as fruit   40
juice, is fed from a deaerator 1 to e blending tank 2 and blended there. Then, the drink is subjected to pasteurisation, normally et a temperature in the range of about 80 to 95°C, and thereafter fed to e saturator 4. Also fed to the saturator 4 are CO_2 and N_2 gases which are supplied from a CO_2 generator 5 and a N_2 generator 6 and are controlled in respect of
45 temperature and quantity by means of valves 7, 8 and a heating tank. When they are fed in a   45
mixed gas form, the gases are mixed in a predetermined ratio by means of a mixer 9, and the mixed gas is fed at a predetermined pressure by means of an automatic pressure regulation valve 10. If the CO_2 ges end N_2 gas are fed separately to the saturator 4, each gas is fed et the predetermined pressure. In this case N_2 gas may be fed in a suitable flow passage located in the
50 former part of the saturator 4. The drink, in which the CO_2 gas and N_2 gas has dissolved under   50
pressure, travels from the saturate 4 through a surge tank 13 to a filler 11 where the drink is filled into cans while holding the pressure applied when dissolving the gases. After a can has been filled, N_2 gas or a mixed gas thereof with a CO_2-containing inert gas is sprayed upon the upper surface of the drink in the can during its exposure to atmospheric pressure before a cover
55 is sealed on the can by a seaming machine 12, whereby the air present in the upper head space   55
region of the can is substantially replaced by these gases before seaming. As stated above, the gas to be sprayed on the open filled can may be N_2 gas alone, or it may be a CO_2 gas-containing inert gas.

In view of the fact that the drink to be filled according to the present invention is a
60 substantially noncarbonated one, however, the CO_2 gas to be dissolved therein under pressure is   60
naturally placed under quantitiative limitetion. The present invention defines the upper limit of the quantities of CO_2 gas dissolved in the drink under pressure as the quantity which falls in taste within the range of noncarbonated drink, namely the weight ratio 15/10,000 to the drink, preferably the weight ratio 5/10,000 or less.
65   With reference to the limitation put on the can internal pressure after the drink containing   65

dissolved CO_2 and N_2 gases has been filled and seamed, the present invention employs, as the filling containers, the aluminium drawn and iron cans (barrel thickness 0.14 mm and bottom plate thickness 0.42 mm) that are most weak in strength of the soft cans with thin wall thickness used in the present invention and have been widely used as highly practical cans for
5 carbonated drinks and utilize them as the basis on which to judge the presence of can   ·   5
deformation. In other words, this means that investigations have been carried out on the premise that if conditions are established so that aluminum drawn and iron cans may not deformed, the normal soft cans with thin wall thickness other than said aluminum drawn and iron cans naturally are not subject to deformation under said established conditions. In the case
10 of the above mentioned drawn and iron cans, it is required that the can internal pressure of said   10
aluminum drawn and iron cans should be held at a pressure less than 8 atm, namely the maximum anti-pressure strength of said cans, at the temperature for subsequent pasteurization to be made by a sterilizing machine or the like after the completion of filling and seaming treatments, namely the heating temperature determined according to drinks being filled such,
15 for instance, as 60°C in the case of fruit juice and 120°C in the case of coffee, and when the   15
cans are cooled to a low temperature of about 5°C suitable for drinking the can internal pressure should be held at a pressure under which the can's original shape may be maintained against the atmospheric pressure and may not be deformed by finger pressure, namely a pressure of 1.1 atm or more, preferably 1.4 atm or more, at 5°C.
20   Now, by plotting the can internal pressure calculated at each temperature in the area   20
surrounded by the ordinates showing the can internal equilibrium pressure after the completion of filling and seaming and the abscissa showing the temperature, there can be drawn a can internal pressure-temperature curve A showing the maximum pressure line (when sterlized by means of a retort at the subsequent pasteurization temperature of 120°C) and a can internal
25 pressure-temperature curve B showing the minimum pressure line as illustrated in Fig. 2. The   25
curve B is a can internal pressure-temperature curve passing the point of 1.4 atm at 5°C.
   Calculation examples of respective plots for drawing respective maximum and minimum pressure lines will be given hereinafter. The following preconditions are established: aluminum cans have a drink filling capacity of 500 ml and a head space of 27.8 ml, CO_2 concentration in
30 a drink is the weight ratio 5/10,000 or less, no chemical changes are occurred in cans after a   30
drink has been filled, can bodies are free from expansion and constriction caused by changes in the can internal pressure, the quantity of residual air at 20°C resulting from spraying of a N_2 or CO_2 gas-containing inert gas upon the upper surface of the can until it is seamed after it has been filled is 3.0 ml and the N_2 gas present therein is calculated as itself, the volume thereof
35 being 80% of the air, the O_2 in the air is 20% and its dissolution in a drink is neglected, and   35
the gases dissolved under pressure are not released in the atmosphere even when exposed to the atmosphere between the filling step and the seaming step.
   Examples for calculating the maximum can internal pressure line and minimum can internal pressure line under the above-mentioned preconditions are given as follows.
40   40

Examples for calculating maximum and minimum can internal pressure lines
   *Factors necessary for calculation (quantity of drink being filled at 20°C 500 ml, head space 27.8 ml and quantity of mingled air 3 ml.)
   1–1 Changes in volume according to temperatures

45   45

Temperature °C	Specific gravity	Water		Volume of aluminum can body ml	Head space ml
		Volume of/g ml	Volume ml		
0	0.99986	1.00013	499.2	527.1	27.9
5	0.99996	1.00004	499.1	527.3	28.2
20	0.99820	1.00177	500.0	527.8	27.8
40	0.99222	1.00784	503.0	528.5	25.5
60	0.98320	1.01708	507.6	529.2	21.6
85	0.96862	1.03239	515.3	530.2	14.9
120	–	–	521.5	531.4	9.9

60   1–2 Bunzen absorption coefficient, vapor pressure of water and O_2 partial pressure of residual   60
air at respective temperatures

Temperature °C	Bunzen absorption coefficient		Vapor pressure of water atm	O$_2$ partial pressure of residual air atm
	N$_2$ gas	CO$_2$ gas		
0	0.0235	1.713	0.006	0.020
5	0.0209	1.424	0.006	0.020
20	0.0155	0.878	0.022	0.020
40	0.0118	0.530	0.072	0.025
60	0.0102	0.365	0.197	0.032
85	0.0095	0.267	0.570	0.049
120	0.0090	0.200	1.960	0.082

Example for calculating O$_2$ partial pressure in head space of can (20°C)

$$\frac{3.0 \times 0.2 \times 1}{273 + 20} = \frac{Po_2 \times 27.9}{273} \qquad Po_2 = 0.020$$

(a) Example for calculating a minimum pressure line

This minimum pressure line denotes the relation between the temperature and the can internal pressure after the completion of filing and seaming treatments in which a can is able to hold its original shape by the can internal pressure when cooled to 5°C. The minimum line obtained herein is capable of holding the can internal pressure in the range of 1.4 atm or more at 5°C. As the CO$_2$ content is determined to be 5/10,000 in weight ratio, its gas Vol/Vol (calculated in terms of 0°C, 1 atm) is obtained as follows:

$$\text{Gas Vol/Vol} = \frac{5}{10000} \times \frac{\text{gas volume in normal state}}{1 \text{ molecular weight}}$$

$$= \frac{5}{10000} \times \frac{22400}{44}$$

$$= 0.2545 \text{ Vol/Vol}$$

(a)−I Next, the state of gas in a can (5°C, 1.4 atm) is calculated.
(i) Partial pressure CO$_2$ gas
It is calculated from Henry's law as follows:
Partial pressure of CO$_2$ gas

$$= \frac{\text{Quantity of dissolved CO}_2 \text{ Vol/Vol}}{\text{Bunzen absorption coefficiency of CO}_2 \text{ at 5°C}}$$

$$= \frac{0.2545}{1.424} = 0.179 \text{ atm.}$$

(ii) Partial pressure of N$_2$ gas
Partial pressure of N$_2$ gas = Can internal pressure − partial pressure of (CO$_2$ + Water vapor + O$_2$)
= 1.4 − (0.179 + 0.006 + 0.020)
= 1.195 atm.
(iii) Total quantity of N$_2$ in can (calculated in terms of 0°C, 1 atm)
Total quantity of N$_2$ in can
= Quantity of N$_2$ dissolved in liquid + Quantity of N$_2$ in head space

$$= 499.1 \times 0.0209 \times 1.195 + 28.2 \times 1.195 \times \frac{273}{278}$$

5   $= 45.558$ ml

(a)–II The state of gas in a can (cooled to 0°C while kept airtight) is calculated.

(i)Partial pressure of CO_2 gas
It is calculated likewise.

10   Partial pressure of CO_2 gas

$$= \frac{0.2545}{1.713 \text{ (Bunzen absorption coefficient of } CO_2 \text{ at } 0°C\text{)}}$$

15

$= 0.148$ atm

(ii)Partial pressure of N_2 gas
Partial pressure of N_2 gas

20

$$= \frac{\text{Total quantity of } N_2 \text{ in can}}{\text{Quantity of } N_2 \text{ soluble in liquid} + \text{Quantity of } N_2 \text{ in head space}}$$

25

$$= \frac{45.558}{499.2 \times 0.0235 + 27.9}$$

$= 1.450$ atm

30

(a)–III Calculation of tha total quantity of CO_2 (calculated in terms of 0°C, 1 atm)
Total quantity of CO_2 gas = Quantity of CO_2 dissolved in liquid + Quantity of gas in head space

35

$$= 500 \times 0.2899 \times 0.878 + \frac{273}{293} \times 27.8 \times 0.2899$$

(partial pressure of CO_2 gas)

40

$= 134.775$ ml

(a)–IV Changes in can internal gas pressure with changes in temperature
Next, an example for calculating the can internal pressure at 60°C is given below. In this
45 connection, it is to be noted that the can internal pressure can be calculated like the
undermentioned case of 60°C in accordance with varied temperatures, and by connecting these
respective plots there can be obtained a minimum pressure line B passing the point of 1.4 atm
at 5°C.

(i)Partial pressure of CO_2 gas
50   When the partial pressure of CO_2 gas at 60°C is yCO_2, the quantity of CO_2 in a can is
134.775 ml. Accordingly, the following equation is established:
$134.775 = 507.6 \times 0.365 \times yCO_2 + 21.6$

55   $\times \dfrac{273}{333} yCO_2$. Hence, $yCO_2 = 0.664$ atm.

(ii) Partial pressure of N_2 gas
When the partial pressure of N_2 gas at 60°C is yN_2, the quantity of N_2 in a can is 45.558 ml.
60 Accordingly, the following equation is established:

$$45.558 = 507.6 \times 0.0102 \times yN_2 + 21.6 \times \frac{273}{333} yN_2.$$

Hence, $yN_2 = 1.991$ atm.

(ii) Can internal pressure
Can internal pressure at 60°C $= 0.664 + 1.991 + 0.197 + 0.032 = 2.88$ atm

(b) Maximum pressure line
In the present invention which uses pasteurized non-carbonated drinks, generally speaking, subsequent pasteurization of fruit juice may be done at 60°C. In the case of fruit juice filled at 60°C, accordingly, there is no need of employing the subsequent pasteurization step. In the case of coffee, which is subjected to sterilization in a retort at 120°C, contrarily, there is necessity of obtaining a can internal pressure-temperature curve A passing the point of 8 atm at 120°C which can be drawn by connecting these plots obtained by calculating the respective can internal pressure in accordance with changes in temperature in the same manner as employed in drawing the aforesaid minimum pressure line.

And, there is necessity of establishing, on dissolving gases in the drink, the other dissolving conditions, namely the ratio of CO_2 to N_2 dissolved in drinks, the pressure for dissolving these gases and the dissolving temperature so as to fall within the range between these curves A and B.

One especially significant characteristic of the present invention may be said to draw a pressure-temperature curve, with the ratio of CO_2 to N_2 in said drink and the pressure for dissolving these gases es parameter, by plotting the CO_2 ratio and the dissolving pressure according to varied conditions in the same area as used in indicating said maximum and minimum pressure lines and connecting said plots.

Since the pressure, epplied when dissolving said gases in drinks, is itself transferred to a can, the maximum is set at 8 atm taking account of the can strength as mentioned above (see a curve C referred to afterwards), but nert there will be obtained respective pressure-temperature curves corresponding to the practical values lower than 8 atm (see curves C'–C''''' referred to afterwards).

In this connection, it is to be noted that our inventors have obtained a surprising discovery that even when the N_2 and CO_2 gases dissolved in a drink under pressure are exposed to the atmosphere during the filling step and the seaming step in the flow sheet in Fig. 1 as aforesaid, said gases are made difficult to escape from the drink by spraying a N_2 gas or a CO_2 gas-containing inert gas upon the upper surface of the can and thus replacing the air of the head space with these gases. According to the present invention, therefore, the CO_2 and N_2 gases dissolved in the drink before the completion of filling and seaming can almost be kept dissolved in the drink.

Therefore, the partial pressure calculated from the quantity of CO_2 and N_2 gases dissolved under pressure, the partial pressure of N_2 in the head space of the can after it has been filled and seamed, the partial pressure of water vapor and the partial pressure of O_2 were summed as follows.

Example for calculating the can internal pressure after filling and seaming
As indicated in the foregoing paragraph, it is necessary that the can internal pressure after filling and seaming should be in the range between above the minimum pressure line and below the maximum pressure line corresponding respectively to the temperature at that time.

On the other hand, since the filling pressure of the filling machine is, as mentioned above, substantially equal to the pressure under which gases are dissolved, the pressure under which gases are dissolved, namely the filling pressure is restricted by the anit-internal pressure strength of the can body. Therefore, the pressure under which gases are dissolved was calculated with reference to the cases of 8 atm (maximum) and further 7 atm, 6 atm, 5 atm, 4 atm and 3 atm respectively.

The can leaving the filling machine is once exposed to the atmosphere and then enters the seaming machine. However, since the can is sprayed with N_2 gas during this, its head space is kept in N_2 gas atmosphere. At this time, however, the head space is regarded as containing 3 ml of the residual air.

(a) In case where the filling temperature is 60°C
(a) Calculation of CO_2 gas in the vapor phase portion of the saturator
Aforesaid total quantity of CO_2 gas in the can 134.775 ml
When the CO_2 gas concentration where gases are dissolved under pressure is χ, respective pressure under which gases are dissolved can be calculated from Henry's law as follows.
(a)–1–1 Pressure under which gases are dissolved 8 atm

$134.775 = 507.6 \times 0.365 \times 8 \times \chi$

$\chi = 0.091$

ⓐ−1−2 Pressure under which gases are dissolved 7 atm

$134.775 = 507.6 \times 0.365 \times 7 \times \chi$

$\chi = 0.104$

ⓐ−1−3 Said pressure can obtained in the like manner as follows.

6 atm...$\chi = 0.121$, 5 atm...$\chi = 0.146$,

4 atm...$\chi = 0.182$, 3 atm...$\chi = 0.243$.

ⓐ−2 Quantities of N_2 gas at respective pressure under which gases are dissolved.

The quantity of N_2 gas at each of said pressure is obtained by summing the quantity of N_2 in liquid, the quantity of N_2 in the head space and the quantity of N_2 in the mingled air calculated as follows.

ⓐ−2−1 Pressure under which gases are dissolved 8 atm

$$507.6 \times 0.0102 \times 8 \times (1 - 0.091) + (21.6 - 3) \times \frac{273}{333}$$

$$+ (3 \times 0.8) \times \frac{273}{333} = 54.867 \text{ ml}$$

ⓐ−2− Pressure under which gases are dissolved 7 atm

$$507.6 \times 0.0102 \times 7 \times (1 - 0.104) + (21.6 - 3) \times \frac{273}{333}$$

$$+ (3 \times 0.8) \times \frac{273}{333} = 49.689 \text{ ml}$$

ⓐ−2−3 Pressure under which gases are dissolved 6 atm

$$507.6 \times 0.0102 \times 6 \times (1 - 0.121) + (21.6 - 3) \times \frac{273}{333}$$

$$+ (3 \times 0.8) \times \frac{273}{333} = 44.522 \text{ ml}$$

ⓐ−2−4 to 6

Likewise, the pressure under which gases are dissolved is calculated to be 39.324 ml at 5 atm, 34.157 ml at 4 atm and 28.974 ml at 3 atm respectively.

ⓐ−3 Calculation of the partial pressure of CO_2 gas in the can

Since the volume of CO_2 gas in the can (calculated in terms of ml, 0°C and 1 atm) is 134.775 ml as shown in ⓐ−1, the partial pressure of CO_2 gas in the can yC can be calculated from the following formula:

$$134.775 = 507.6 \times 0.365 \, yC + \frac{273}{273 + 60} \times 21.6 \times yC$$

$yC = 0.664$ etm

ⓐ−4 Calculation of the partial pressure of N_2 gas in the can since the volume of N_2 gas in the can (calculated in terms of ml, 0°C end 1 atm) is as indicated in ⓐ−2, when the partial pressure of N_2 gas in the can is yN, the following formulas are established.

ⓐ−4−1

Pressura under which gases are dissolved 8 atm

$$54.867 = 507.6 \times 0.0102 \, yN + \frac{273}{273 + 60} \times 21.6 \, yN$$

$yN = 2.398$ atm

(ⓐ) 4–2
Pressure under which gases are dissolved 7 atm

5   $49.689 = 507.6 \times 0.0102\ y\text{N} + \dfrac{273}{273 + 60} \times 21.6\ y\text{N}$ 5

$y\text{N} = 2.171$ atm

10   (ⓐ)–4–3 to 6   10
When the pressure under which gases are dissolved is 6 atm, 5 atm, 4 atm and 3 atm, $y\text{N}$ is
likewise calculated to be 1.945 atm, 1.718 atm, 1.492 atm and 1.266 atm respectively.
(ⓐ) 2–5
Calculation of the total can internal pressure
15   · The total can internal pressure is equivalent to the sum of [(ⓐ)–3 . . . the partial pressure of   15
CO_2], [(ⓐ)–4 . . . the partial pressure of N_2], [the partial pressure of H_2O] and [the partial
pressure of O_2]. Therefore, the total can internal equilibrium pressure just after the completion of
filling and seaming treatments, which corresponds to each pressure under which gases are ·
dissolved, is given below, wherein the filling temperature is 60°C. These sum ·values are plotted
20   in the drawing (Fig. 2).   20

Pressure under which gases are dissolved atm	Partial pressure of CO_2 atm	Partial pressure of N_2 atm	Partial pressure of H_2O atm	Partial pressure of O_2 atm	Total sum atm
8	0.664	2.398	0.197	0.032	3.291
7	0.664	2.171	0.197	0.032	3.064
6	0.664	1.945	0.197	0.032	2.838
5	0.664	1.718	0.197	0.032	2.611
4	0.664	1.492	0.197	0.032	2.385
3	0.664	1.266	0.197	0.032	2.159

(ⓑ) According to the same procedure as employed in case where the temperature is 60°C,
there are calculated the can internal pressure after the completion of filling and seaming
40   treatments by varying the values of the pressure under which gases are dissolved at respective   40
temperatures. These values are plotted in said area surrounded by the ordinates and the
abscissa. By connecting these plots there can be obtained curves C, C', C'', C''', . . .
(ⓒ) Calculation of the pressure-temperature curve of the CO_2 ratio in the gas
The can internal pressure-temperature curve after the completion of filling and seaming
45   treatments was calculated from the pressure under which gases were dissolved and the   45
temperature wherein the ratio of CO_2 to N_2 and CO_2 gases dissolved in the drink under pressure
was considered constant. Said calculation was made in accordance with the procedure employed
in the instance of the ratio of CO_2 to gases against the dissolving pressure at the temperature of
60°C.
50   On the other hand, the can internal pressure was measured by filling and seaming under   50
various conditions using the line for filling carbonated drinks to confirm that the above
mentioned logically assumed values were substantially practicable.
As the result, a practical drawing has been completed which is capable of clarifying at a
glance the relations between the can internal equilibrium pressure after the completion of filling
55   and seaming and the conditions necessary for filling (such as the filling temperature, the ratio of   55
CO_2 to gases and the pressure under which gases are dissolved).
A diagram as shown in Fig. 2 (which will be called KH diagram hereinafter) can thus be   ·
prepared. If the conditions such as the quality, dimensions, strength caused thereby, volume,
volume of head space and the like of the soft can with thin wall thickness are established, there
60   may be drawn the respective KH diagrams corresponding to the respective established   60
conditions.
When dissolving the gases in the drink is effected under the conditions in the range
surrounded by the maximum can internal pressure curve A, the minimum can internal pressure
curve B and the can internal pressure-temperature curve C passing the point of 8 atm, the can
65   internal pressure after the completion of filling and seaming comes to fall within the   65

predetermined range which is entirely free from can deformation, whereby it becomes possible to fill the soft with thin wall thickness with noncarbonated drinks.

Referring to the conditions requisite for the actual filling operation using Fig. 2, they may be determined as follows. Taking the case of firstly regulating the dissolving temperature, the
5 allowable range of the pressure under which gases are dissolved can be obtained between either   5
lower line of the curve A or curve C and the curve B in the manner of extending the specified temperature point of Fig. 2 upwards, end the ratio of CO_2 to gases can be determined in the manner of selecting any one of the dissolving pressure included among this range and finding said ratio at the intersecting point of said dissolving pressure with the temperature. Alternatively,
10 it is also possible to obtain the allowable range of the ratio of CO_2 to gases between the curve A   10
or curve C and the curve B at said specifically determined dissolving temperature and then select any one of the CO_2 ratios included among this range thereby to obtain the dissolving pressure. The thus obtained dissolving temperature, dissolving pressure and CO_2 ratio ere all employable as reference conditions.
15   As is evident from the above KH diagram, it can be seen therefrom that the dissolving (filling)   15
temperature may be selected from the wide range of 20–81°C for instance in the 500 ml-aluminum can which constitutes one of the preconditions in Fig. 2. Accordingly, the present invention may be said to have a hitherto wholly unexpected effect that in the case of filling fruit juice, the subsequent pasteurization step may be omitted by raising the filling temperature to
20 60°C or more. By preparing the KH diagram like this beforehand, it is mede possible to obtain   20
the respective dissolving (filling) conditions so as to meet the object of the present invention. Accordingly, the dissolving pressure and CO_2 ratio to be used in the filling at temperatures higher than those in the prior art may also be obtained very easily from the KH diagram, the possibility of said filling at higher temperatures having been confirmed and put in practice first
25 by the present invention.   25

According to the present invention as described above, energy can be economized very effectively because the respective KH diagrams can be prepared based on the determined conditions such as the kind of drink to be filled, the quality of can, the dimensions end volume thereof and the like, the conditions requisite for filling can be readily determined from said KH
30 diagram, and further filling can be effected especially at high temperatures. The present   30
invention may be said serviceable for economy in energy considering that not only the usual line for filling carbonated drinks in soft cans with thin wall thickness or line for filling noncarbonated drinks in hard cans such as steel can and the like and the devices thereof, as they stand or modified slightly. may be used for filling noncarbonated drinks in soft cans with thin wall
35 thickness but also it becomes possible to fill both carbonated and noncarbonated drinks in the   35
same soft cans with thin wall thickness such, for instance, as aluminum drawn and iron cans, whereby standerdizetion of cans to be used can be attained.

Example
40   A 500 ml-aluminum drawn and iron can (barrel thickness 0.14 mm and bottom plate   40
thickness 0.42 mm) was filled with 10% fruit juice by the use of the apparatus shown in Fig. 1 and in accordance with the procedure illustrated therein. In the KH diagram according to the above mentioned preconditions, namely Fig. 2, dissolving was carried out under the conditions: the dissolving temperature 60°C, the pressure for dissolving the mixed gas et that time 6 atm,
45 and the ratio of CO_2 gas in the mixed gas 12% (the weight ratio of CO_2 gas to the drink   45
5/10,000). During the exposure of the filled can to the atmosphere, a N_2 gas was sprayed upon the upper surface of the can and then the can was seamed. The can after the completion of filling and seaming was cooled to 5°C. This can was observed to be free from deformation completely even when the finger pressure was applied thereonto.
50   On the other hand, a N_2 gas and a CO_2 gas were fed to the saturator separately and dissolved   50
therein under pressure by repeating the exactly same procedure as mentioned above. The same results were obtained in this case, too.

CLAIMS
55   1. A method of filling a "soft" thin walled can, for example an aluminium can, with a   55
substantially non-carbonated drink, in which method N_2 gas and CO_2 gas are dissolved under pressure in the drink so that the weight ratio of CO_2 to the drink is a predetermined value which is not more than 15/10,000, a predetermined quantity of the drink is then introduced into the can et the same temperature and pressure at which the N_2 and CO_2 gases were dissolved in the
60 drink, and N_2 gas and/or a CO_2 containing inert gas is supplied over the surface of the drink in   60
the can, substantially replacing the air in the head space of the can, while the can is open between the filling and sealing of the can, the temperature, pressure, and CO_2 to N_2 ratio at which the CO_2 and N_2 gases are dissolved in the drink having been determined by establishing, for the sealed can filled with the predetermined quantity of a drink containing dissolved CO_2 and
65 N_2 gases with the predetermined weight ratio of CO_2 to the drink, an upper can internal   65

pressure-temperature curve passing through a predetermined maximum pressure at a selected high temperature and a lower can internal pressure-temperature curve passing through a predetermined minimum pressure at a selected low temperature to define a permissible can internal pressure-temperature range, a first series of can internal pressure-temperature curves
5 assuming the dissolving pressure to be held constant at a series of different values at and below   5
the predetermined maximum can internal pressure, and a second series of can internal pressure-temperature curves assuming the CO_2 to N_2 ratio to be held constant at a series of different values, and determining the dissolving pressure and the CO_2 to N_2 ratio at a selected temperature from any curve of the first and second series which lies within the permissible can
10 internal pressure-temperature range at the selected temperature.   10
    2. A method according to claim 1, in which the predetermined maximum can internal pressure is 8 atmospheres.
    3. A method according to claim 1 or claim 2, in which the predetermined minimum can internal pressure is 1.1 atmospheres at 5°C.
15   4. A method according to claim 1 or claim 2, in which the predetermined minimun can   15
internal pressure is 1.4 atmospheres at 5°C.
    5. A method according to any one of the preceding claims in which the non-carbonated drink is fruit juice, coffee, black tea, cocoa, lactobacillus drink, wine, rice wine (sake), soup, tea, barley tea, isotonic drink, or still mineral water.
20   6. A method according to any one of the preceding claims, in which the weight ratio of the   20
dissolved CO_2 gas to the drink is 5/10,000 or less.
    7. A method according to any one of the preceding claims, in which the N_2 gas and CO_2 gas are dissolved in the drink as a gas mixture.
    8. A method according to any one of the preceding claims, in which the can is an
25 aluminium can.   25
    9. A method according to any one the preceding claims, in which the dissolving and filling temperature is in the range of from 20° to 81°C.
    10. A method according to claim 9, in which the proportion of CO_2 gas in the gases dissolved in the drink is from 5% to 13%.
30   11. A method according to claim 9 or claim 10, in which the pressure under which the   30
gases are dissolved in the drink is in the range of from 3 to 8 atmospheres.
    12. A method according to any one of claims 9 to 11, in which the dissolving and filling temperature is 60°C.
    13. A method according to any one of the preceding claims, in which the gases supplied
35 over the surface of the drink in the can consist of a mixture of N_2 gas and CO_2 gas.   35
    14. A method according to any one of claims 1 to 12, in which the gas supplied over the surface of the drink in the can is N_2.
    15. A method according to claim 1, substantially as described with reference to the accompanying drawings.
40   16. A method of filling non-carbonated drinks comprising the steps of dissolving a N_2 gas   40
and a CO_2 gas under pressure in a blended and then pasteurised non-carbonated drink, under respective dissolving conditions, the weight ratio of CO_2 gas to said drink being 15/10,000 or less; filling this drink in soft cans with thin wall thickness at respective filling conditions; spraying a N_2 gas or a CO_2 gas-containing inert gas upon the upper surface of the can during
45 the exposure time extending from filling to seaming so as to replace the air present in the head   45
space with these gases; and thereafter seaming the can, wherein said dissolving conditions include the dissolving temperature, pressure for dissolving the gases in the drink and ratio of CO_2 to N_2 dissolved in the drink, and are obtained in a manner of establishing a can internal pressure-temperature curve range between above a can internal pressure-temperature curve
50 passing the point of 1.1 atm at 5°C and below a can internal pressure-temperature curve   50
passing the point of 8 atm at a heating temperature for subsequent pasteurisation by plotting in the area surrounded by the ordinates showing the can internal pressure after completion of filling and seaming and the abscissa showing the temperature, determining the CO_2 ratio and the dissolving pressure which fall within said can internal pressure-temperature curve range at
55 respective temperature by plotting in aforesaid area the can internal pressure after completion of   55
filling and seaming which can be obtained by changing the ratio of CO_2 to N_2 dissolved in the drink and the pressure for dissolving these gases in the drink within the maximum range of 8 atm, and finding respective dissolving conditions which fall within the can internal pressure-temperature curve range, and said filling conditions are the same conditions as employed on
60 dissolving.   60